NASA Langley Colloquium Series

Sigma Public Lecture Series

Space Exploration: Filling Up the Canvas

Michael D. Griffin

Administrator

National Aeronautics and Space Administration

24 October 2006

Thank you for inviting me to speak at this colloquium; I am truly honored. This lecture series dates back to 1971, with the inaugural address by Wernher von Braun, and many other luminaries from our industry have followed him, so I have big shoes to fill. I started my career in the aerospace business in that same year. Maybe there is a young person in this audience who will be giving the 70th anniversary lecture on the then-future of space exploration, thirty-five years from now.

This area of our country, Virginia, has given birth to many great leaders and explorers, whose ideas for our nation's future speak to us across the generations as we carry out the great task before us in space exploration. No event in our history more aptly conveys those ideas and lessons than does the Lewis and Clark expedition, which concluded exactly 200 years ago. When discussing this great expedition, led by Virginians Meriwether Lewis and William Clark, fellow Virginian Thomas Jefferson wrote, "The work we are now doing is, I trust, done for posterity in such a way that they need not repeat it. We shall delineate with correctness the great arteries of this country. Those who come after us will fill up the canvas we began."

Today, we are endeavoring to "fill up the canvas" of our solar system in such a way that our work is done for posterity as well. When President Bush laid out the canvas for NASA with the Vision for Space Exploration nearly three years ago, he evoked the Lewis and Clark expedition, saying: "Two centuries ago, Meriwether Lewis and William Clark left St. Louis to explore the new lands acquired in the Louisiana Purchase. They made that journey in the spirit of discovery, to learn the potential of vast new territory, and to chart a way for others to follow. America has ventured forth into space for the same reasons. We have undertaken space travel because the desire to explore and understand is part of our character."

When President Bush set this new course for America's space program, the White House issued a supporting document explaining why. Quoting from that policy, "The fundamental goal of this vision is to advance U.S. scientific, economic, and security interests through a robust space exploration program." I believe that this is exactly right, and that the benefits to be derived in these respects from such a program were exactly the same ones that Jefferson expected to derive from the Louisiana Purchase and from the expedition he sent out to begin its assessment.

Security in Jefferson's time meant establishing the primacy of the infant United States across the breadth of the North American continent, in an era when numerous competitors for this primacy existed, and today's nation, stretching "from sea to shining sea", was the vision of farseeing men like our third president, but few others.

The Lewis and Clark expedition paved the way for future adventures by the new nation in what eventually became the American west. Indeed, would it even have become the "American" West without the staggering success of this first great westward trek? At the time of their expedition, Spain, France, England, and

Russia had interests and a presence in what is today the western United States. This is a message that speaks to us today, across two centuries of time, as we contemplate the future of humans in the solar system.

In our time, while we certainly recognize that the United States will be only one nation among many on the space frontier, we have learned that "security" can involve much broader concerns than competition among nation-states. The Chairman of the NASA Advisory Council, Harrison Schmitt, geologist, Apollo 17 astronaut, and former United States Senator, and Stephen Hawking, cosmologist and Lucasian professor of mathematics at the University of Cambridge, have both pointed out this fundamental truth: The history of life on Earth is the history of extinction events. There is evidence, now, for some five major extinction events in the history of the Earth. The last of these occurred approximately 65 million years ago, at the end of the Cretaceous Period, when the dinosaurs that dominated the Earth for over 160 million years suffered a catastrophic extinction over a relatively short period. It is believed that this event was induced by an asteroid of some 6-15 kilometers in diameter which struck the Earth in the Gulf of Mexico, triggering tsunamis, tectonic shifts, and radically changing the Earth's atmosphere.

The brief history of humans is next to nothing compared to the history of other life on Earth, and even less so compared to the age of our solar system or of the universe. Our species hasn't been around long enough to have experienced a cataclysmic extinction event. But they will occur again, whether we are ready for them or not. So, in the end, human expansion into our solar system is fundamentally about the survival of the species, about ensuring better odds for our survival through the promulgation of our species. There is no more fundamental measure of "security".

But security is not the only reason to explore. History shows clearly that there is an economic benefit to be derived from exploring new territories.

Jefferson understood this. When he proposed the Lewis and Clark expedition in a secret message to the Congress, he said: "While other civilized nations have encountered great expense to enlarge the boundaries of knowledge by undertaking voyages of discovery, and for other literary purposes, in various parts and directions, our nation seems to owe to the same object, as well as to its own interests, to explore this, the only line of easy communication across the continent, and so directly traversing our own part of it. The interests of commerce place the principal object within the constitutional powers and care of Congress, and that it should incidentally advance the geographical knowledge of our own continent, cannot be but an additional gratification."

Likewise, the Vision for Space Exploration recognizes the economic benefits to be derived from space exploration. As the President's Science Advisor Jack Marburger stated in a speech earlier this year, "Questions about the vision boil down to whether we want to incorporate the Solar System in our economic sphere, or not. Our national policy, declared by President Bush and endorsed by Congress last December in the NASA Authorization Act, affirmatively answers that question: The fundamental goal of this vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program."

In this vein, the U.S. segment of the International Space Station has been designated a national laboratory, open for commercial manufacturing and advances in materials sciences due to its unique microgravity environment. To that end, I commend the Langley Research Center's material scientists for recently retrieving 200 specimens from the MISSE suitcase with the Space Shuttle. Working with the Naval Research Laboratory and others, these experiments may lead to more advanced solar arrays, and help researchers make materials and coatings which last longer on Earth.

On the Moon, there are resources to be mined, including hydrogen, oxygen and maybe one day helium-3, which could be of special benefit in establishing a permanent lunar presence. An armada of satellites from the United States, India, China, and Japan is set to map the Moon's geography and resources over the next several years in anticipation of future human exploration and, potentially, lunar settlements. Of particular interest are the Moon's polar regions, where some locations enjoy near-permanent sunlight, while others only a few kilometers apart are permanently shadowed. The former are obviously of tremendous benefit in establishing a lunar base, because of the ability to generate nearly continuous solar power. And in the shadowed regions, it is possible that water ice deposited by cometary impact might be found, preserved from evaporation by the sun's heat. If such ice exists, it would be a boon for a future lunar base, enabling the occupants to "live off the land" more easily than carrying all provisions with them from Earth.

But this rosy prospect is at present still a conjecture. While there is some evidence to support it, there remains considerable debate among lunar scientists as to whether such conditions truly exist at the poles, and if so, how much ice is there. We won't know until we conduct a better survey. This debate among lunar scientists is not unlike the debate about the unknown geography of our own North American continent at the time of the Lewis & Clark expedition.

The next robotic lunar missions will test our assumptions and challenge our beliefs. But one assumption that I know will be justified is that the Moon, the near-Earth asteroids, and the rest of the solar system contain the resources that will take mankind to the next level of civilization and prosperity. I don't know when it will occur or who will do it, but it will happen. I hope that it will be soon, and that we will be the agents of this great endeavor.

Jefferson was the most scientifically literate president our nation has had, and he fully understood that his bold expedition would, almost automatically, open a new realm of scientific discovery. Jefferson's instructions to Meriwether Lewis in June, 1803 read like a NASA requirements document today: "explore the Missouri river, and such principal stream of it as by its course and communication with the waters of the Pacific Ocean whether the Columbia, Oregon, Colorado or any other river may offer the most direct and practicable water communication across this continent for the purposes of commerce." Jefferson's additional requirements for the Lewis and Clark mission: "[Y]ou will take careful observations of latitude and longitude at all remarkable points on the river…Other objects of worthy notice will be the soil and face of the [territory] its growth and vegetable productions,…the animals of the [territory],…the mineral productions of every kind; but more particularly metals: limestone, pit-coal, and salt-petre; salines and mineral waters,…volcanic appearances, and climate." This was advanced scientific inquiry for that day.

For NASA, exploration is about the expansion of human and robotic activity out beyond the Earth. This sets the stage for scientific opportunities which we are just now beginning to consider. Soon, we will begin to add to the body of knowledge for our civilization concerning the real estate values in cislunar space, and we will conduct scientific experiments along the way, much in the fashion that Meriwether Lewis and William Clark gathered specimens, made careful observations in their journals, and drew detailed maps of the American west 200 years ago.

Jefferson's plans were comprehensive, yet flexible. The hoped-for water route to the Pacific did not, in fact, exist. Yet, because the expedition did not have a single overriding goal, it was an enormous success. This should also be our strategy when making plans to explore the Moon and Mars. We should expect to

be surprised, and we should adjust our exploration plans as we learn more about the lay of the land before us, its resources and environmental conditions.

If we are able to live and work on the Moon, we will not only use its resources for our survival and economic benefit. We will think of ways to exploit its unique vantage point and environment to further our scientific goals. Back in 1990, the National Academy of Sciences studied the suitability for using the Moon as a stable platform, without an atmosphere and having predictable heating and lighting, for astronomical observatories, especially interferometers. Going into the next decadal study for astronomy and astrophysics, the Academy should consider how we can better leverage the exploration architecture to further scientific pursuits "and other literary purposes" as Jefferson would say, so that we can plan our expeditions appropriately.

So, what is our approach to achieving the goals of which I have spoken here?

Our nation's Vision for Space Exploration honors our previous commitment to the International Space Station, and at the same time commits us to bold new journeys to the Moon, Mars, and eventually the rest of the solar system, to learn the potential of this vast new territory and chart a way for others to follow. With our Russian, European, Japanese, and Canadian partners, the United States is completing the assembly of the International Space Station. We will then retire the Space Shuttle in 2010, less than four years from now. Meanwhile, we are beginning to build new space ships and rockets to carry astronauts and, one day, future settlers outward from low Earth orbit.

The scientists and engineers of Langley Research Center are integral to turning this vision into reality. Experts in structures, materials and other disciplines in the aerospace sciences, along with the NASA Engineering and Safety Center that is hosted at Langley, helped return the Space Shuttle to flight after the

Columbia accident. Their work has been instrumental in understanding the physics behind foam loss on the external tank, and its effects on the Shuttle thermal protection system. Langley engineers worked on the CFD analysis to support the removal of the Shuttle External Tank PAL ramps. All of this was absolutely crucial to the future of our agency; absolutely nothing good can happen at NASA unless we can fly the Shuttle with confidence that we have fixed the problems that brought down *Columbia*.

Looking to the future, the NESC organized a "smart buyer" team across the agency earlier this year to conduct an "in house" design of our *Orion* Crew Exploration Vehicle, so that managers and engineers could better evaluate industry designs and sharpen the systems engineering and integration skills needed to manage this major undertaking. And a project team hosted at Langley is managing the *Orion* Launch Abort System, which we hope to test beginning in 2008. Others are working on the *Orion* landing system vertical drop tests with the half-scale crew module. And yet others have conducted wind tunnel tests of the *Ares 1* Crew Launch Vehicle to characterize the launch vehicle stack.

This stuff *is* rocket science! As an engineer myself, I fully appreciate the challenges before us, and frankly, we should all recognize that the development of the arts and sciences of spaceflight is quite simply the most technically challenging thing our nation, or any nation, does. Meriwether Lewis's perspective on the challenges he faced ahead of him on July 4th, 1805 speaks to many of us in NASA today: "We all believe that we are now about to enter on the most perilous and difficult part of our voyage, yet I see no one repining; all appear ready to meet those difficulties which wait us with resolution and becoming fortitude."

We must also recognize the dangers involved. Virginian David Brown, no less an explorer than any on the Lewis & Clark expedition, died with his fellow crewmates on Space Shuttle *Columbia*. A graduate of William & Mary and

Eastern Virginia Medical School, David once said that even in the case of a possible catastrophe for his upcoming mission, “The program will go on. It must go on.”

Thomas Jefferson was equally cognizant of the perils awaiting the Lewis and Clark expedition. In his letter of instructions to Meriwether Lewis, Jefferson wrote: “As it is impossible for us to foresee in what manner you will be received by the native people, whether with hospitality or hostility, so it is impossible to prescribe the exact degree of perseverance with which you are to pursue your journey. We value too much the lives of our citizens to offer them to probable destruction… To your own discretion therefore must be left the degree of danger you risk, and the point at which you should decline to continue, only saying we wish you to err on the side of your safety, and to bring back your party safe even if it be with less information that you will have acquired to that point.” For the record, Lewis and Clark succeeded admirably in this matter, while still achieving the larger goals of their venture. Only one man was lost on the expedition, from what was believed to have been a burst appendix, an ailment which could not have been treated in that era in any case.

Some days our journey into space must appear altogether boring to the casual observers, the pundits, or the “chattering class”, as they’re sometimes called in Washington, who are not steeped in the trials and tribulations of great challenges. The critics will never appreciate the hard but tedious work, and the sheer joy, that goes with the successful accomplishment of every Space Shuttle flight, or a record-breaking hypersonic flight like that of the X-43A, or the development of a new satellite capability, like the CALIPSO LIDAR instrument managed at the Langley Research Center.

This also is not new. The daily entries in the Lewis and Clark journals are sometimes filled with “nothing to report” as well, as the men of the Corps of

Discovery and their female Indian interpreter Sacagawea endured the daily rains in Oregon. However, historians have noted the three words in Meriwether Lewis's journal that are often-repeated, and are the most important in understanding the character of those making such a journey: "We proceeded on." Lewis repeats this phrase in his journal on many days, after attacks by native Indians and grizzly bears, after seeing great bison stampedes, after capturing a prairie dog, after back-breaking portages with their canoes, after gazing upon the daunting mountain ranges which they had to traverse to reach the west coast of America. Indeed, "we proceeded on" evokes the sense of determination that David Brown expressed about our basic human need to explore.

The Vision for Space Exploration carries on the tradition of exploration embodied by two Virginians of whom we have spoken tonight, Meriwether Lewis and William Clark, two hundred years ago. They carried out their mission for very similar reasons that we carry out our mission today – national security, economic gain, and scientific discovery. While space exploration is certainly fraught with difficulty and peril, we can at the same time both appreciate those risks and yet believe that for the same reasons as existed two hundred years ago, this is truly the most rewarding endeavor our nation will pursue in the 21st century.

When Lewis and Clark and other members of the Corps of Discovery returned and, subsequently, were feted for their accomplishments in Washington, one senator remarked that they appeared "as if they had returned from the Moon". How apt. The Lewis and Clark expedition embodied the pioneering spirit which is characteristic of our nation, the spirit which led us forward to the Apollo 11 lunar landing by Neil Armstrong and Buzz Aldrin. Lewis and Clark made "one giant leap for mankind", right along with Armstrong and Aldrin. New leaps will soon follow.

The next steps in returning to the Moon and moving onward to Mars, the near-Earth asteroids, and beyond, are crucial in deciding the course of future space exploration. We must understand that these steps are incremental, cumulative, and incredibly powerful in their ultimate effect. As President Bush pointed out when announcing the Vision for Space Exploration, “We will make steady progress – one mission, one voyage, one landing at a time.” Further, we must understand that there is no turning back. In the words of David Brown: “It must go on.”

Allow me to end with the thoughts of Meriwether Lewis on the day he turned thirty-two years old. Lewis was on one of the greatest journeys of his time, of any time, yet he did not realize its significance while he was doing it. Instead, he was consumed with the great mission before him. Jefferson once opined that Lewis suffered from a certain melancholy when it came to his work. Meriwether Lewis wrote the following passage of enlightenment in his journal on August 18, 1805: "This day I completed my thirty first year, and conceived that I had in all human probability now existed about half the period which I am to remain in this Sublunary world. I reflected that I had as yet done but little, very little, indeed, to further the happiness of the human race, or to advance the information of the succeeding generation. I viewed with regret the many hours I have spent in indolence, and now sorely feel the want of that information which those hours would have given me had they been judiciously expended. But since they are past and cannot be recalled, I dash from me the gloomy thought, and resolved in future, to redouble my exertions and at least endeavor to promote those two primary objects of human existence, by giving them the aid of that portion of talents which nature and fortune have bestowed on me: or in future, to live for mankind, as I have heretofore lived for myself."

So, in conclusion, I really do hope that there is a young person in the audience today who, many years from now, will continue the tradition of this

lecture series by telling us how she helped to fill up the canvas, breaking the confines of this “sublunary” world.

Thank you.